Scalable Ultra Power-Dense Extended Range (Super) Inverter

Project ID: elt280

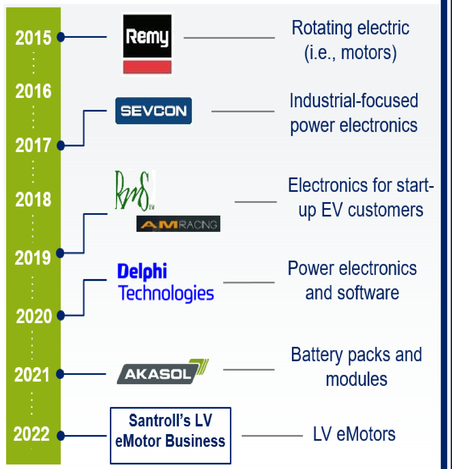
OVERVIEW

- **Project Start** – Oct. 2021
- **Project End** – Dec. 2024

Total Project Funding - $6.24M
$5.0M (Fed) & $1.24M (Non-Fed)
Total FY2022 - $2.65M

BACKGROUND

- BorgWarner is now the largest North American producer of hybrid electric vehicle (HEV) and EV components. We supply any combination of electrification components such as inverters, chargers, DC/DC converters, battery management systems, domain controllers, on-board charger and DC/DC combination units as well as and 3-in-1 propulsion drive-unit systems.
- Project Charging Forward initiative set to grow revenue to 45% of total revenue by 2030.
- BorgWarner has developed and demonstrated state-of-the-art (SOTA) power semiconductor solutions and building block technologies to reduce traction inverter size and cost.



TECHNOLOGY INNOVATION AREAS

- Highly integrated and epoxy overmolded *power module* with double-sided cooling, permitting operational junction temperature at or just below 200°C. Subsequently, enabling a higher current carrying capability with similar or less WBG (i.e., SiC) active material area, while maintain low system losses.
- Next generation *cooling module* with novel fin structure enabling a scalable and cost-effective solution. Permitting high temperature and performance values based on the new power module requirements.
- Next generation *capacitor technology* with high temperature (> 160°C) capability and self-healing properties as well as 300% higher energy density. Enabling significant volume reduction in power stack (i.e., power modules, capacitor and busbar) sub-assembly for inverter packaging.
- New electrical control architecture based on next generation *µC and ASICs* providing faster feedback loop for sensing, control, and actuation. To achieve performance and efficiency targets as well as realizing future functional safety requirements (i.e., ASIL-D).

EXPECTED OUTCOME

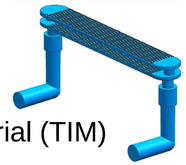
- Develop, build, and verify new inverter concept with prototype power stack based on a new power module design in conjunction with a novel thermal solution and high temperature capacitor technology as well as new control architecture.

NEXT STEPS

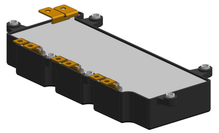
- Component requirements, design, simulation as well as system architecture and packaging studies.

≥ 190°C junction temp SiC die
≥ 230°C die bonding material
> 800Vdc and ≥ 650Arms

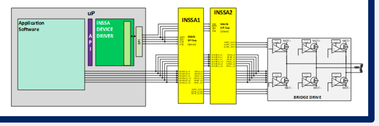
Copper alloy cooling module
Novel fin w/ low delta pressure
Next gen thermal interface material (TIM)



Nano-lamination structure
Integrated DC busbars
≥ 1000Vdc



Next gen µC & ASIC
Smart Gate Driver
Current Sensing IC



CHALLENGES

- Access/availability of prototyping machinery and material composition for die-attach as well as over molding within small design space (i.e., thickness).

OBJECTIVE

- Develop and demonstrate traction inverter to meet DOE's 2025 targets of *100kW/L power density at or below $2.7/kW cost.*

PROJECT TIMELINE

Year 1 (Q4-21 – Q4-22)	**Research, Technology Down Selection and Component Design**
Year 2 (Q1-23 – Q4-23)	**Component and Subassembly Verification and System Design**
Year 3 (Q1-24 – Q4-24)	**Prototype Manufacturing and Verification/Validation (V&V)**

KEY PARTNERS

- **Infineon Technologies Americas Corp. -** Leading supplier of semiconductor devices used in automotive, industrial, commercial and high reliability applications.
- **Wolfspeed, Inc.** (Vendor) **-** Provider for > 60% of the SiC wafers used in the SiC power semiconductor industry.
- **PolyCharge America, Inc. -** Strategic developer and commercializing its solid-state polymer nanolaminate (Nanolam™) capacitor technology for use in inverters of HEVs and EVs.
- **National Renewable Energy Laboratory (APEEM) –** Research partner on advanced thermal management.
- **Virginia Polytechnic Institute & State University –** Research partner on power processing and distribution.

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

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